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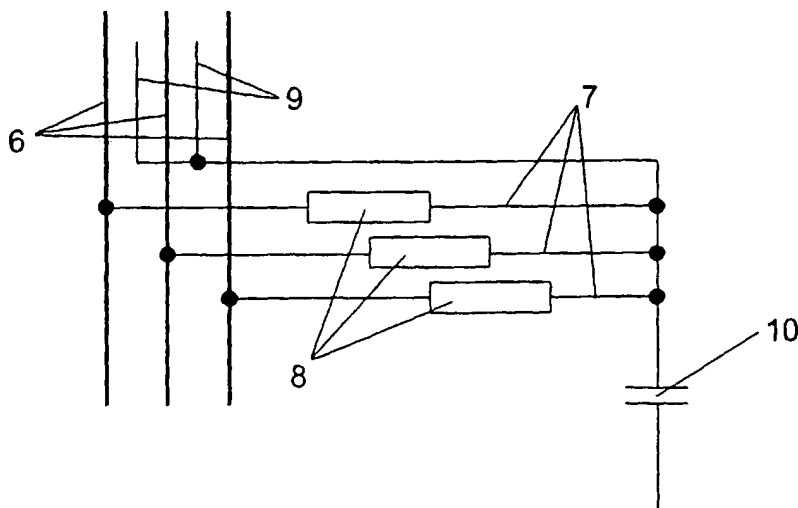
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(54) Title: DROP-ON-DEMAND PRINTER



(57) Abstract: A drop-on-demand printer having a row of ink ejection locations (2) for ejecting plural ink droplets, each ejection location (2) having an associated ejection electrode (40) to which a voltage is applied for causing electrostatic ejection of the droplets from the respective ejection location (2); a guard channel (5) disposed between adjacent ejection locations (2), each guard channel (5) having an electrode (50) disposed therein; and control means for applying a voltage to said guard channel electrodes (50), said applied voltage being the average of the voltages applied in operation over a given time to the adjacent ejection location electrodes.

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## DROP-ON-DEMAND PRINTER

The present invention relates to a drop-on-demand printer of the type in which an agglomeration of particles is created and then ejected, by electrostatic means, onto a printing substrate. More particularly, the invention relates to such a printer having a row of ink ejection locations for ejecting plural ink droplets, such as described in our WO-A-93-11866.

Such printers may be manufactured with very small spacings between adjacent ink ejection locations, in which case, it is desirable to reduce electrostatic cross-talk between adjacent locations or channels. This can be achieved by incorporating guard channels between pairs of ejection channels. Such printers are usually operated by means of a bias voltage applied continuously to the ejection locations through appropriate ejection electrodes and, when ejection is required, applying suitable pulse voltages to the ejection electrodes. The bias voltage may also be continuously applied to the guard channels. However, when the ejection electrodes associated with two or more adjacent ejection locations are pulsed continuously, a high field is created between the ejection locations and the intervening guard channels and fluid may be forced from the ejection locations to the guard channels and from there may be ejected onto the substrate. It is desirable therefore to reduce the possibility of such erroneous ejection.

According to the present invention therefore there is provided a drop-on-demand printer having a row of ink ejection locations for ejecting plural ink droplets, each ejection location having an associated ejection electrode to which a voltage is applied for causing electrostatic ejection of the droplets from the respective ejection location; a guard channel disposed between adjacent ejection locations, each guard channel having an electrode disposed therein; and control means for applying a voltage to said guard channel electrodes, said applied voltage being the average of the voltages applied in operation over a given time to the adjacent ejection location electrodes.

A second aspect of the invention includes a drop-on-demand printer having a row of ink ejection locations for ejecting plural ink droplets, each ejection location having an associated ejection electrode to which a voltage is applied for causing electrostatic ejection of the droplets from the respective ejection location; a guard channel disposed between adjacent ejection locations, each guard channel having an electrode disposed therein; and control means for applying a voltage to said guard channel electrodes, said applied voltage being the average of the voltages applied in operation over a given time to the ejection location electrodes.

The control means also preferably applies a bias voltage to the guard channel electrodes with which the average voltage is summed. Also preferably, each guard

channel electrode is connected to a bias voltage through a capacitance. Similarly, each guard channel electrode may be connected to the adjacent ejection location electrodes through resistances of equal value.

5 The invention also includes a method of operating a drop-on-demand ink jet printer having a row of ink ejection locations for ejecting plural ink droplets, each ejection location having an associated ejection electrode for causing electrostatic ejection of the droplets from the respective ejection location, and a guard channel disposed between adjacent ejection locations and having an electrode disposed therein, the method comprising applying a voltage to said guard channel electrodes, said applied voltage being the  
10 average of the voltages applied in operation over a given time to the adjacent ejection location electrodes.

Further, the invention includes a method of operating a drop-on-demand ink jet printer having a row of ink ejection locations for ejecting plural ink droplets, each ejection location having an associated ejection electrode for causing electrostatic ejection of the  
15 droplets from the respective ejection location, and a guard channel disposed between adjacent ejection locations and having an electrode disposed therein, the method comprising applying a voltage to said guard channel electrodes, said applied voltage being the average of the voltages applied in operation over a given time to the ejection location electrodes.

20 The invention also includes a drop-on-demand printer having a row of ink ejection locations for ejecting plural ink droplets, each ejection location having an associated ejection electrode to which a voltage is applied for causing electrostatic ejection of the droplets from the respective ejection location; a plurality of guard channels disposed between adjacent ejection locations, each guard channel having an electrode disposed  
25 therein; and control means for applying a voltage to at least some of said guard channel electrodes.

Two examples of printers according to the present invention will now be described with reference to the accompanying drawings in which:

Fig. 1 illustrates a print head of the type described in our WO-A-98-32609;  
30 Fig. 2 illustrates the electrical connections to the ejection channels and guard channels of the printer shown in Fig. 1;

Fig. 3 illustrates the relationship over time of the voltages on the guard channels;

Fig. 4 illustrates alternative electrical connections to the ejector and guard channels of a printer;

35 Fig. 5 illustrates a circuit for providing the voltages required; and,

Fig. 6 illustrates an alternative design of print head, similar to that of Fig. 1, but employing multiple guard channels between adjacent electrode locations.

Fig. 1 shows a cross-section through part of a multi-channel ejection print head 1, the figure showing three ejection locations 2, defined by upstands 3, on each side of which is provided an ejection channel 4 having an ejection electrode 40 as described in our WO-A-98-32609, for example. Guard channels 5 are provided between each pair of ejection locations, i.e., on each side of each ejection location 2 and have similar electrodes 50.

Fig. 2 illustrates the electrical connections to both the ejection channels 4 and the guard channels 5, the electrical paths 6 (ejection conductors) to the ejection channels being connected to suitable voltage drivers (not shown in Fig. 2), and having connections 7 which include a 100M $\Omega$  resistance 8 as shown, connected to each guard channel conductor 9. A bias voltage is continuously applied through a 100pF capacitance 10 so that, as the required pulses are applied to the ejection conductors 6, appropriate RC-averaged voltages are applied to the guard channels 5. This method is suitable for providing the required voltages where the guard channels are connected together.

The circuit shown above has a time constant of 10ms and when not printing, the guard channels 5 are all held at the bias voltage. When printing with a 50% duty cycle from all channels, the guard channels reach the average of the pulse and bias voltages after about 30ms and when printing with a 90% duty cycle at 5Hz from all the channels, the guard channels reach the bias voltage plus 90% of the pulse voltage after about 30ms as shown in Fig. 3.

It should be noted that in the circuit shown in Fig. 2, the guard channel conductors 9 are all connected together and the RC average of all ejection channels 4 is applied to the guard channel electrodes 50 thereby. A more complex, but advantageous approach to the electrical connections is as shown in Fig. 4, in which an isolated guard channel electrode 50 has the RC average voltage of the two neighbouring printing/ejection channels 4 applied to it (via the conductors 9), by virtue of the bias voltage being applied individually to each guard channel 5 through a respective 100pF capacitance, and each guard channel conductor 9 being individually connected to the two adjacent ejection channels through a 100M $\Omega$  resistance 8.

Fig. 5 illustrates a circuit capable of providing the required voltages to the respective ejection and guard channels and uses the same nomenclature/reference numerals. Pulse voltage generators are illustrated at 11 and a common bias voltage generator is indicated at 12, both being controlled by a suitable controller 13.

The print head illustrated in Fig. 6 is very similar to that shown in figure 1 and the same reference numerals are used. However, the print head has three guard channels 5, 15, between the adjacent ejection locations 2, the outer pair of channels 15 being arranged as 'flanker' channels and having their respective associated electrodes (not

shown) electrically connected to each other and to the ejection electrode they surround. In this case, the central guard channel 5, can be maintained at the average of the ejection electrodes as described previously. In an alternative (not shown) the flanker channels 15 adjacent to the central guard channel 5 are connected together and to the guard channel 5 they surround and can be maintained at the average of the ejection electrodes as described previously.

## CLAIMS

1. A drop-on-demand printer having  
a row of ink ejection locations for ejecting plural ink droplets, each ejection  
5 location having an associated ejection electrode to which a voltage is applied for  
causing electrostatic ejection of the droplets from the respective ejection location;  
a guard channel disposed between adjacent ejection locations, each guard  
channel having an electrode disposed therein; and  
control means for applying a voltage to said guard channel electrodes, said  
10 applied voltage being the average of the voltages applied in operation over a given  
time to the adjacent ejection location electrodes.
2. A drop-on-demand printer having  
a row of ink ejection locations for ejecting plural ink droplets, each ejection  
15 location having an associated ejection electrode to which a voltage is applied for  
causing electrostatic ejection of the droplets from the respective ejection location;  
a guard channel disposed between adjacent ejection locations, each guard  
channel having an electrode disposed therein; and  
control means for applying a voltage to said guard channel electrodes, said  
20 applied voltage being the average of the voltages applied in operation over a given  
time to the ejection location electrodes.
3. A drop-on-demand printer according to claim 1 or claim 2, wherein the control  
means also applies a bias voltage to the guard channel electrodes, with which the  
25 average voltage is summed.
4. A drop-on-demand printer according to claim 3, wherein each guard channel  
electrode is connected to a bias voltage through a capacitance.
- 30 5. A drop-on-demand printer according to claim 1, wherein each guard channel  
electrode is connected to the adjacent ejection location electrodes through resistances of  
equal value.
6. A drop-on-demand printer according to claim 2, wherein each guard channel  
35 electrode is connected to each ejection location electrode through resistances of equal  
value.

7. A drop-on-demand printer according to any of claims 1 to 6, including plural guard channels between adjacent electrode locations.
8. A method of operating a drop-on-demand printer having a row of ink ejection locations for ejecting plural ink droplets, each ejection location having an associated ejection electrode for causing electrostatic ejection of the droplets from the respective ejection location, and a guard channel disposed between adjacent ejection locations and having an electrode disposed therein, the method comprising  
5 applying a voltage to said guard channel electrodes, said applied voltage being the average of the voltages applied in operation over a given time to the adjacent ejection location electrodes.
9. A method of operating a drop-on-demand printer having a row of ink ejection locations for ejecting plural ink droplets, each ejection location having an associated ejection electrode for causing electrostatic ejection of the droplets from the respective ejection location, and a guard channel disposed between adjacent ejection locations and having an electrode disposed therein, the method comprising  
15 applying a voltage to said guard channel electrodes, said applied voltage being the average of the voltages applied in operation over a given time to the ejection location electrodes.
10. A method according to claim 8 or claim 9, wherein a common bias voltage is applied to said guard channel electrodes.
11. A method according to claim 10, wherein said common bias voltage is applied through a capacitance.
12. A method according to claim 8, wherein said average voltage is applied by connecting each guard channel electrode to the adjacent ejection location electrodes through resistances of equal value.
13. A method according to claim 9, wherein said average voltage is applied by connecting each guard channel electrode to the ejection location electrodes through resistances of equal value.
14. A drop-on-demand printer having a row of ink ejection locations for ejecting plural ink droplets, each ejection location having an associated ejection electrode to which a



voltage is applied for causing electrostatic ejection of the droplets from the respective ejection location; a plurality of guard channels disposed between adjacent ejection locations, each guard channel having an electrode disposed therein; and control means for applying a voltage to at least some of said guard channel electrodes.

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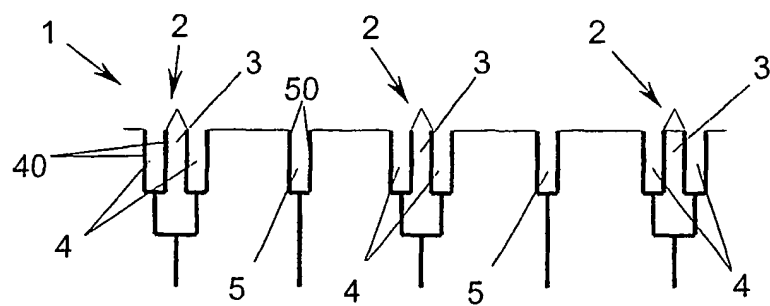


Fig. 1

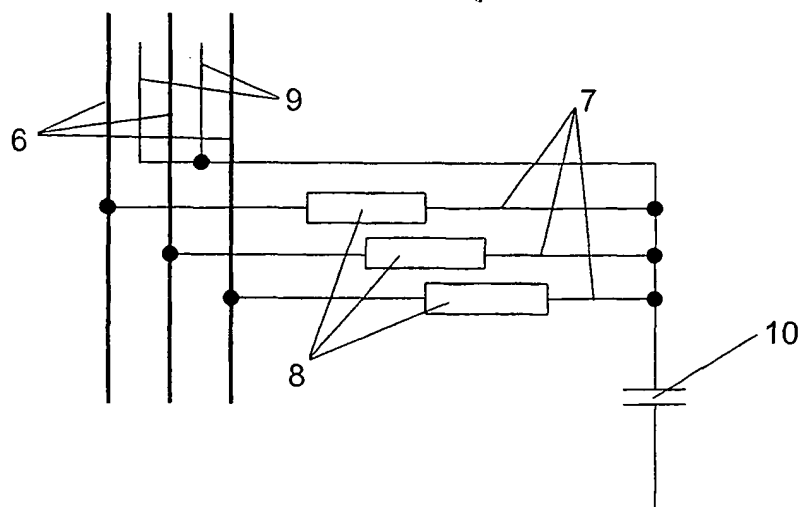


Fig. 2

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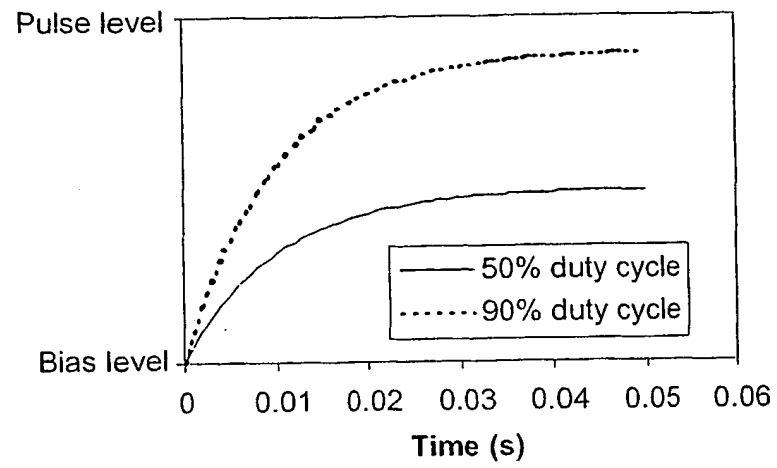


Fig. 3

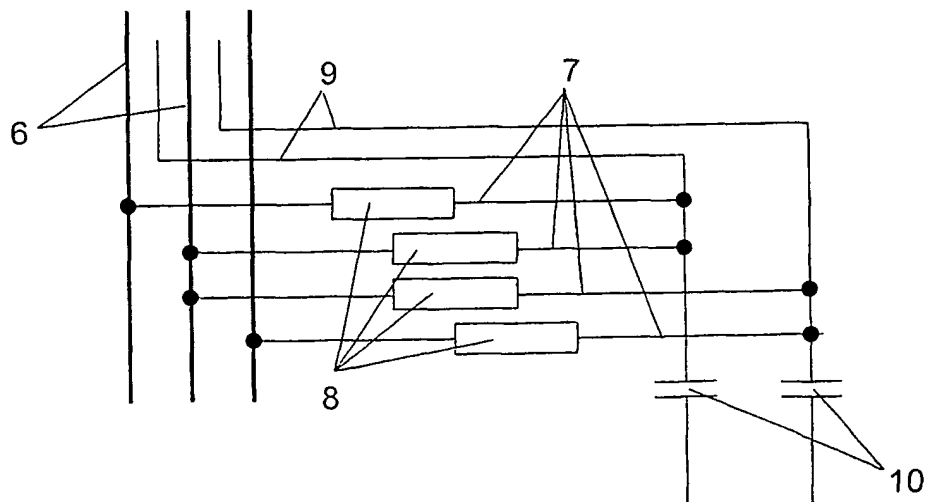


Fig. 4

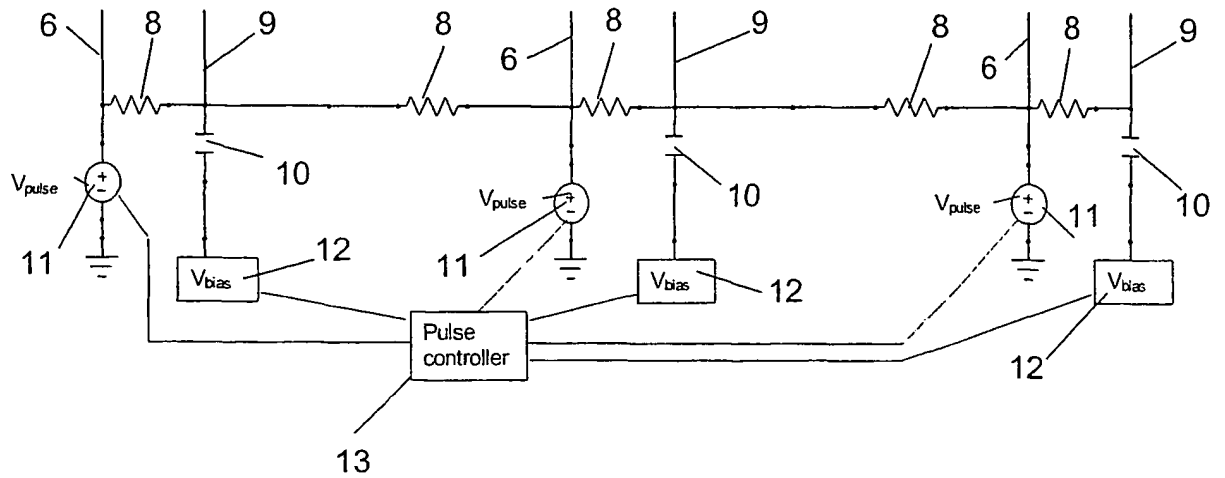


Fig. 5

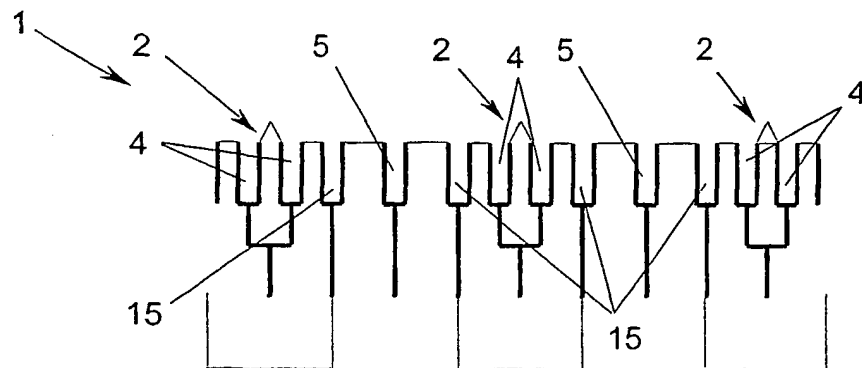


Fig. 6

## INTERNATIONAL SEARCH REPORT

PCT/GB 02/00193

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 B41J2/06

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 B41J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 98 32609 A (TONEJET CORP PTY LTD ;MACE DANIEL RICHARD (GB); ATKIN PHILIP (GB);) 30 July 1998 (1998-07-30) cited in the application page 3, line 22 -page 5, line 27; figures 1,3-5	1-14
A	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 04, 31 August 2000 (2000-08-31) & JP 2000 025236 A (MURATA MACH LTD), 25 January 2000 (2000-01-25) abstract --- -/--	1-14



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Patent family members are listed in annex.

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## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 16, 8 May 2001 (2001-05-08) & JP 2001 001524 A (MATSUSHITA ELECTRIC IND CO LTD), 9 January 2001 (2001-01-09) abstract ---	1-14
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JP 2000025236	A	25-01-2000	NONE	
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JP 2001001524	A	09-01-2001	NONE	
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JP 10337872 4	A		NONE	
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